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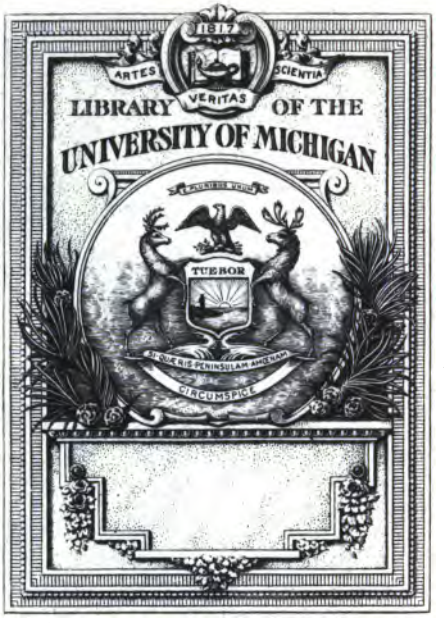

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International Fisheries Exhibition 91

LONDON, 1883

THE SCIENTIFIC RESULTS OF THE EXHIBITION

BY

PROFESSOR Sir E. Ray LANKESTER

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International Fisheries Exhibition.

LONDON, 1883.

CONFERENCE ON FRIDAY, JULY 20, 1883.

HIS GRACE THE DUKE OF ARGYLL IN THE CHAIR.

THE SCIENTIFIC RESULTS OF THE EXHIBITION.

THE text which has been selected for the Paper which I have the honour to submit on the present occasion has caused me no little perplexity on account of its ambiguity.

It has been pointed out to me that it is unwise to prophesy unless you know, and that no one at present can know what may be the results, scientific or otherwise, of the great Exhibition, which has still some months of its career to run.

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Again, it is apparent that the word "scientific" has a very wide scope, including statistical, mechanical, hydrographical, biological and sociological results, all of which are in some way or other to be observed and studied in the great International Fisheries Exhibition.

The comprehensive vagueness of the title of my discourse has consequently the advantage that it permits me to choose from a very wide range of subjects, and I have accordingly to submit to you the following as a more exact definition of the matter to which I desire to call your attention. I propose not to speak so much of scientific

results which may flow from the Exhibition, as of scientific results which are illustrated in the Exhibition, and in particular of those results of the science of *Zoology* which are of importance to the Fish Industry, and are more or less completely set forth for our instruction and edification in the collections which have been brought together in the London International Fisheries Exhibition.

It would have been a congenial task to me to describe here some of the rare specimens of great interest to the zoologist, which have been sent by foreign countries to this exhibition, such specimens as Nordenskjold's Phytina and the magnificent skeletons of Ziphioid Whales shown in the Swedish court are of surpassing interest and importance from the zoological point of view. At the same time it must be admitted that they do not have any special importance in relation to Fisheries, and accordingly I must leave unnoticed such rarities and delights of the zoologist, in order to address myself more especially to the question of the relationship of the science of zoology to the fish industry.

The value of zoological science in relation to fisheries is not, I think, so fully appreciated in this country as is desirable in the interests of the public, and of those who make profit by enterprise in fisheries.

There is a very general tendency among men whose occupations are of a commercial character to undervalue the work of scientific inquiry, not only in regard to such matters as fisheries and fish-culture, but also in relation to manufacturing industries, agriculture, mining, and even in relation to medicine. To a large extent this arises from a misconception as to the real nature and character of what is called "science." Science is the knowledge of causes; its method and purpose when strictly pursued lead to the

accumulation and arrangement of thorough and accurate knowledge of any given subject to which it may be applied, with a certainty and an abundance which no other method and no other purpose can give. Undoubtedly the latest scientific knowledge of a subject is very usually not *immediately* useful to those who are engaged in applying commercial enterprise to the same subject. It is however to be noted, over and over again, that the scientific discovery of one generation becomes the necessary foundation of some valuable commercial enterprise in the next: what was at one time a curiosity and of little interest, save to men of science, becomes after fifty years the pivot of some great industrial manufacture.

Accordingly commercial men, and those who place the material well-being of this country beyond all things as an object to be continually striven for, should have patience in the presence of what seem to be the useless accumulations of knowledge; they should have faith in the ultimate utility of science, for already throughout the length and breadth of the land this cause-reaching knowledge, which we call "science," has proved its enormous power of aiding commerce, and has amply established its claim to not merely toleration but to eager and generous support from those who are reaping golden harvests through the science of a past generation.

When we remember that science is really no more nor less than such accurate and full knowledge of this or that class of natural things as enables us actually to understand "the causes of things," then it becomes obvious that the distinction which is sometimes drawn between the "scientific" man and the "practical" man is founded upon some kind of error. If there is the antithesis which fashion causes many persons to assert as existing, let us see what

becomes of it when we say, as we are justified in saying, that the scientific man is the man who knows thoroughly and accurately. The contrast insisted on between the scientific and practical man becomes, then, simply the contrast between the man who knows and the man who does not know, but acts in ignorance.

As a matter of fact there is no such antithesis. Your man of science is, or should be from the nature of his pursuits, more thoroughly practical than any one who affects to despise scientific knowledge, for he is accustomed to insure success in his experiments and investigations by taking every means in his power to that end ; above all, and chiefly, by guiding himself by reasonings based on the most accurate and extensive knowledge. So too, indeed, every so-called practical man who is not a mere adventurer—a happy-go-lucky tempter of Fortune—makes use of accurate knowledge to aid him in his commercial ventures and speculations ; so far as he can get it, he makes use of science, though he often calls it by some other name as soon as it becomes useful knowledge.

The fact is, that a large part of the indifference to science in this country, and the notion that science is dreamy, vague, untrustworthy and useless to practical men, has arisen from the fact that these worthy practical men have very often allowed themselves to be imposed upon by mere quacks and pretenders, who assume the language and authority of science without any credentials whatever, and lead the practical men astray. Such quackery in science has been by no means unusual in this country, owing to the almost complete destitution of the wealthy classes in respect of scientific education. Practical men have, as a rule, not even a smattering of scientific training, and cannot distinguish true from false science, cannot tell which is the

quack and which the man of real knowledge. Equally unfortunate in this respect, in former times, have been the members of the executive and deliberative branches of our successive governments, so that—in days which we may hope are past—ignorant pretenders to scientific knowledge have been, in good faith, placed in responsible positions, and have helped to justify the notion that modern science is a wind-bag of theories, and of little use to the practical man.

Such causes—namely a general mistrust of so-called science, and to a small extent a painful experience in especial connection with fisheries, of the results of placing confidence in quacks who have falsely pretended to scientific knowledge—seem to me to be accountable for the fact that in the British Islands, neither publicly nor privately, has there been any attempt to make use of the services of scientific men in relation to our fisheries. The recent appointment of the distinguished naturalist who is at present Inspector of Salmon Fisheries, is evidence of a new disposition to seek the aid of the highest authorities in science in connection with this subject; but it must be remembered that salmon fisheries form but a very small part of British fisheries in their entirety, and that a large staff of experienced naturalists would be required to deal satisfactorily, within a reasonable time, with the many important problems presented by the British Sea Fisheries.

The Governments of some foreign States, notably of France, but also on a smaller scale of Norway and Sweden, Holland, Prussia, Saxony, and in a special, and in many respects very noteworthy, manner, that of the United States of America, have concerned themselves to obtain the aid of zoologists in developing and managing the resources of the fish industries of their respective territories. The

results of the application of accurate knowledge concerning fishes, and such shell-fish as oysters, mussels, pearl-mussels, lobsters and cray-fishes, have been in some cases strikingly successful; in other cases time has yet to show what advantages may result from the attempts which have been made. In all these countries, however, one very distinct result of the appreciation of the possible value of scientific knowledge of fishes and shell-fish by the State authorities has been this, namely, that zoologists are occupying themselves independently, and with increasing earnestness, with the investigation of all that relates to the life and growth, the food and the enemies, of the marine and freshwater organisms which form the material basis of fisheries.

In the present Exhibition, accordingly, we see not a few of these scientific results exhibited in the courts assigned to foreign exhibitors; whilst, on the other hand, in the British department there is very little which comes under the head of zoological science at all, that is to say, which illustrates the results of exact inquiry into the natural history of the fishes and other animals which are such an immense source of wealth and industry to our seafaring population.

Before proceeding to enumerate and describe these scientific collections, I should wish briefly to explain in what ways it seems probable that the accurate knowledge with regard to fishes which is now being accumulated by zoologists may hereafter be useful in the regulation and management of fisheries.

In any given area of land or water, under natural conditions, where animals can obtain nourishment, there is found living (taking one year with another) fully as much animal life as can there nourish and reproduce itself. Practically the whole of the earth's surface and of the sea

is fully taken up by plants and animals. Many thousands more of most kinds are annually born than can possibly survive to maturity. The number of each kind of animal in natural conditions does not increase; but there is a strict balance maintained, so that, with local exceptions here and there, those that survive to maturity in the struggle for existence merely replace those which have gone before. Many thousands of young perish, serving as nourishment for other lower and higher organisms, whilst the total number of mature organisms remains the same.

Take as an example the microcosm constituted by a pond in which carp are cultivated, as in Germany, where these fish are valued as food.[1] Such a pond is allowed to remain dry every fourth year, when it is cleansed and puddled. Water is then allowed to run in, and a given number of one-year-old carp are placed in it. After three years these are taken out and sold as food. In one such pond 30,000 young carp have been observed constantly to yield at the end of three years 20,000 kilogrammes of marketable carp; when more than 30,000 young carp have been placed in the pond, no greater yield has resulted, 20,000 kilos. weight of carp-fish is the result of that pond's activity after three years. The food of the carp consists of delicate vegetable growths, of insects, and other minute aquatic animals. These hatch from eggs and spores introduced with the water into the pond, and the pond will only carry such an amount of this food as will in three seasons produce 20,000 kilos. of carp-flesh. It is further found necessary to keep with these carp in the same pond a few pike, which prey upon the carp to a certain extent. The carp-culturists know how many pike to introduce. A few act beneficially in destroying the smaller and more

[1] I borrow this illustration from Professor Möbius of Kiel.

sickly individuals of the carp-stock, and so prevent valuable vegetable and insect-food from being consumed by individuals who would either not survive for the three years, or would show no growth proportionate to their consumption of food. On the other hand, too large a number of pike would reduce the total weight of carp, and leave much of the minute food in the pond unconsumed, whilst a large portion of it would have been converted into pike-flesh instead of remaining as carp.

In the limited area of the carp-pond there are a great number of processes going on, which contribute to the ultimate production of the 20,000 kilos. of carp-flesh. The minute vegetable organisms are continually feeding on the carbonic acid absorbed by the water from the atmosphere, and on the nitrogen partly existing originally as nitrates and ammonia therein, partly returned to the water by the excretion and decay of its animal inhabitants. Minute worms and crustacea are feeding on these plants, and other larger insects are feeding on these; finally, the carp nourish themselves on all these living things, and are to some extent preyed upon by the pike. Definite physical conditions, such as the presence or absence of a stream in the pond, the extreme heat and cold of summer and winter, and the presence of saline constituents in the water, determine the excess or the absence of one or another of the lower forms. If only *one* of these conditions be varied, the whole balance may be upset. An excessive growth of some minute plant, such as an Oscillatoria, favoured by heat or by the destruction of some other organism, may lead to the destruction of the proper food of the carp, and the yield of the pond may be endangered. The whole of these circumstances can, in the case of the carp-pond, be studied and controlled.

If we now pass to the consideration of any given area of the sea-bottom, we find that, though the area is not definitely limited, the same interaction of the various organisms inhabiting it, holds good. One form is preying upon another, and determining by its presence the numbers and the interaction of all the others. Physical conditions which affect one form, may in the same way, as in the carp-pond, affect the prosperity and abundance of another form. Currents, varying seasons, and such-like conditions, must obviously produce their effect. But still more influential must be the operations of man in removing a large number of edible fish from such an area. It is a mistake to suppose that the whole ocean is practically one vast store-house, and that the place of the fish removed on a particular fishing-ground is immediately taken by some of the grand total of fish, which are so numerous in comparison with man's depredations as to make his operations in this respect insignificant. Even were it proved that there is this sort of cosmopolitan solidarity about such fish as the Cod, which live in deep water, there is, on the contrary, evidence that shoal fish, like Herrings, Mackerel and Pilchard, and ground-fish, such as Soles and other flat-fishes, are really localised. If man removes a large proportion of these fish from the areas which they inhabit, the natural balance is upset, and chiefly in so far as the production of young fish is concerned. It is true that several thousand young are produced by each pair of fish left in the breeding area, and it might be argued that since, in the absence of man, only two out of the many thousand born of each pair of fish come to maturity and breed again in their turn, the only result of man's depredations (in addition to the depredations of other enemies) is to make way for more of the young, and to enable *more* than two of

the many thousands born of each pair in a preceding generation to survive and breed in their turn. This argument is at once seen to be fallacious when we remember that the thousands of *apparently* superfluous young produced by fishes are not really superfluous, but have a perfectly definite place in the complex interaction of the living beings within their area. These very young fish serve as food to other forms, which in their turn are fed upon by others, and are so interwoven with the necessities and conditions of life of other inhabitants of the area, that to remove, say something like a fifth or even a tenth of them from that area by removing the parent fish, must cause a serious disturbance in the vital balance of that area. When the fisherman removes a large proportion of soles from a given area, and so reduces the number of young soles born in the same season in that area, he does not simultaneously destroy the natural enemies of the young soles : consequently very nearly the same number of young soles are destroyed by such natural enemies as were so destroyed before man interfered, although very many less young soles are produced. It is thus quite clear that there is in reality no reserve stock of young to take the place of the adults removed by the special interference of man. The increasing scarcity of the sole is a serious fact, and is thus to be explained.

From this point of view it is clearly important, if we wish to keep up the number of food-fishes in an area which is fished by man, or to increase that number, that we should (1) either know what are the natural enemies of the food-fish in question at various stages of its growth, and seek to destroy those enemies in proportion as we remove the adult fish ; (2) or, again, that we should isolate and protect the young fish from these natural enemies for a part of their

lives; (3) or, lastly, that we should, in proportion as we remove breeding fish from the area, artificially introduce into that area eggs, or young fish hatched under supervision, so as to supply the deficit created by the fishery of egg-producing adults.

Any of these operations requires very considerable and most accurate zoological knowledge, and it would be madness to attempt to carry any of them out by proceeding upon hasty guesses or suppositions as to the habits and life-history of the animals concerned.

There is also no doubt that certain modes of fishing and seasons of fishing may be more destructive, more disturbing to the balance of life in a given area, than other modes and other seasons of fishing. The food of the fish which are valued, may be destroyed by some of man's operations, their enemies may be unwittingly encouraged by others. Legislation is continually demanded, and has been from time to time carried out, in reference to such matters as modes and seasons of fishing and pollution of waters. But it is undeniably true that, in most cases, the accurate knowledge as to the life-history and circumstances of fishes is too small to justify legislative interference. No doubt zoologists have suggested some valuable restrictions which have been adopted by the Legislature in regard to some fisheries, and it is to Linnæus, the great Swedish zoologist of the last century, that Sweden owes important fishery laws. But if we are to have effective legislation at the present day in regard to our sea fisheries—we must, before proceeding any further, have *more knowledge*. Those (and there are many) who earnestly desire additional restrictive Fishery Laws should do their utmost to enable zoologists to carry on researches which will provide that accurate knowledge of fishes and shell-fish, their food-reproduction

and conditions of life—which must be obtained before legislation can reasonably be proposed.

The only mode of deciding between the conflicting opinions which have so often been expressed during this Congress, as to the necessity of this or that legislative enactment, is by bringing new knowledge to bear upon the questions at issue. That new knowledge is nothing more nor less than a part of Zoological Science, and can only be obtained through the exertions of those who are already acquainted with the actual condition of that science, and with its methods of minute and thorough investigation.

It is apparent, then, that the results of zoological science as they may possibly effect fisheries, must even at the present moment be very considerable. We may classify them as follows:

1st. The discrimination and classification of the different kinds of plants and animals, including the fishes themselves which inhabit the various fresh and sea waters where fisheries are carried on. This is what is known as the study of Systematic Zoology, and of the fauna and flora of districts.

2nd. The knowledge of the successive phrases of development or growth from the egg, and of the internal anatomy and mechanism of life of the chief forms of such animals and plants. This constitutes what is known as General Morphology and Physiology.

3rd. A specially detailed knowledge of the life-history of those species of fishes, molluscs, and crustacea, which are valuable to man and are the subject of fisheries; a knowledge of their migrations, susceptibility to external influences, of their food and its history in detail; of their enemies, in the shape of other fishes, birds, whales, seals, and insects, &c., which prey upon them and their young;

a knowledge of their parasites, injurious or harmless, and of their diseases. Such knowledge may be termed the Special Biology of Economic Fishes.

4th. A knowledge of those particular features in the life-history of an economic fish or mollusc, which directly concern the work of the fisherman or the fish culturist; a knowledge of the effects produced by particular fishing operations, as shown by statistics, or of the effects produced by particular methods of preservation and culture: further, a special knowledge of those parts or qualities in economic fishes or molluscs which are of commercial value, and a knowledge of methods of improving or securing those parts or qualities. This group of topics constitutes what may be called Pisciculture.

Coming under the first head—of Systematic Zoology—there are some valuable collections in the present Exhibition, but on account of the large space which they would occupy were they complete, such collections are, on the whole, rather samples of larger collections than attempts at complete illustration of the marine or fresh-water inhabitants of a district. Thus, Dr. Dohrn of Naples has sent a series of about 400 bottles containing specimens in a marvellous state of preservation, accurately named, of the fishes, crustacea, molluscs, annelids, star-fishes, corals and jelly-fish of the Bay of Naples. Mr. Oscar Dickson sends also a very beautiful collection of named specimens from the Gothenburg Museum, illustrating the fauna of the neighbouring sea. Professor Lilljeborg exhibits in the Swedish department a very large scientifically named collection of the crustacea which form the food of many fishes in the great fresh-water lakes of Northern Europe. He has especially occupied himself with the study of these organisms, and has discovered many new species; it is

worthy of remark that English naturalists only two years ago became alive to the fact that the same fresh-water crustacea exist in the English and Scotch lakes. It is quite possible that a proper knowledge of these crustacea may at some future day be of value in attempts to cultivate fish in British lakes. Marine birds and mammals are exhibited in various parts of the Exhibition. Dr. Francis Day exhibits his great collection of Indian Fishes—preserved in spirits and accompanied by the coloured plates, of his great book on Indian Ichthyology: he also exhibits a collection of British fishes carefully preserved and named. The American department is remarkable for the carefully coloured series of casts, representing different species of the American food-fishes, and for samples of the animals of lower classes obtained from considerable depths off the American coast. Complete collections of the edible crustacea and mollusca of the United States, and of the commercial sponges of the coast of Florida, are also exhibited.

Under the second head—viz. General Morphology and Physiology—there is very little to be noted in the Exhibition. In fact, when we have mentioned the series exhibiting the growth of the salmon from the egg onwards, exhibited by Professor McIntosh of St. Andrews, and the series of flat fishes of various ages in Mr. Oscar Dickson's collection—there is nothing except the valuable drawings of the anatomy of the oyster, and of its development from the egg, exhibited by the Netherlands Society of Zoologists. Under the auspices of this Society, which possesses a movable house fitted as a zoological laboratory, which can be erected for temporary use on any part of the Dutch coast—two Dutch naturalists, Dr. Hoek and Dr. Horst, have within the past two years made some careful studies of the oyster which have very greatly added to our know-

ledge of that important mollusc, and may eventually be of service to the oyster-culturist. The results obtained by these observers are shown by large coloured drawings exhibited in the Netherlands department.

Some results of zoological science coming under the third head, viz. Special Biology of Economic Fishes, are to be found scattered here and there in the Exhibition. Collections of insects injurious to fish or to their eggs and young, are exhibited in the Swedish Court, also, in a small way, in the American Court. A few parasites of fishes are exhibited by Dr. Cobbold, in the Eastern Arcade, and a remarkable series of the crustacean parasites, or fish-lice, of the fishes of Trieste is shown by Dr. Antonio Valli in the Austro-Hungarian section. Fish diseases are represented by stuffed specimens of salmon, with cotton wool attached, indicating the position of the growths of Saprolegnia which cause the malady.

The fourth section into which we have divided the results of zoological science, as seen in the Exhibition—namely that of the various developments of pisciculture—is richly represented by the exhibits of English oyster-culturists and salmon farmers; but in the most interesting way in the American department, where the devices made use of for hatching the eggs of sea-fish are shown. I need hardly say that the artificial hatching of the eggs of sea-fish is a novelty, and distinctly a result of the application of scientific knowledge. Since the culture of marine and of fresh-water fishes has formed the subjects of special papers at this Congress, I will not venture to say anything further about it here beyond claiming it as a scientific result.

There appears to be no exhibit in the building relating to the Pearl fisheries, either marine or freshwater; in relation to these we should anticipate that the application

of scientific knowledge might produce some very definite results (in the way of pearl-production).

Sponge fisheries are represented by collections of sponges from Florida, from the Bahamas, and from the Greek Islands. In the collection from Florida is a specimen having a very definite scientific interest. It represents an attempt at sponge-culture. Some years since in the Adriatic—under the Austrian Government—Professor Oscar Schmidt made some experiments on the propagation of sponges by cuttings. It was found possible to cut a live sponge into pieces, and affix these pieces each to a separate slate by thread, when each piece would attach itself to its slate and continue to grow. In this way sponges can be transported from one area to another—but the total weight of sponge is not increased, for the pieces of the divided sponge only produce the same amount of new sponge as they would have done had they never been separated from one another.

It appears that sponge-cutting is being attempted on the Florida coast, and in the American Court are two sticks with sponge-cuttings growing upon them, which have been artificially placed there. I am not aware as to whether any valuable result has been obtained by thus cutting the sponges; but it is certain that they might be thus introduced into artificial basins, and grown there, were the general conditions in such basins favourable.

Coral fishery is represented by an exhibit from Naples, and by three pieces of valuable red coral from Japan which have been purchased for commercial purposes at a high price. The eminent French zoologist, Lacaze Duthiers, under the direction of the French Government, made a very thorough study of red coral, and obtained scientific results of great importance, fitted to assist the coral fishermen in the regulation of their fisheries and the culture of coral; but

these results are not in any way illustrated in the present Exhibition.

On the whole, it appears when one attempts to enumerate the results of zoological science in relation to fisheries—illustrated in the present Exhibition—that there are but few results which are so illustrated—in fact not nearly so many as one might have expected. But, on reflection, it will appear that it is difficult to show, in the form of a tangible exhibit, many of these results. They are for the most part to be found in books, and in the memoirs and illustrative drawings published by scientific societies. Microscopic preparations, showing every detail of the growth from the egg—of the oyster, the mussel, the lobster, the sole, the cod, and salmon, are hardly to be looked for. Really complete zoological collections would be too cumbrous for transport and exposure in such an Exhibition. But above all it is true that many of the most important scientific conclusions affecting the interests of fisheries are not capable of exhibition. The instruments with which the investigations are made, and in some cases the animals which have been the subject of investigation, may be exhibited, but the scientific result can often only be *exhibited* in so far as it affects the procedure of fish-catchers, fish-breeders, or fish-culturists.

I think that it has been made very apparent, not only by the class of objects exhibited by foreign contributors to this Exhibition, but also by the original papers and the discussions which the Conferences connected with the Exhibition have produced, that there is nothing which is so much needed in connection with all kinds of fisheries, river or sea, shell-fish, true fish, coral or sponge—as more knowledge, more science—in fact, more zoology; and not only that, but that there is nothing which is more desired

and recognised as needful *by all those who are best informed in their own particular branches of fishery.*

Improved machines for catching fish, new legislative restrictions, State aid to fisher-folk—all such desiderata are, I believe, admitted to be less urgently needed, less likely to prevent our various fisheries from deteriorating or disappearing altogether, than the one desideratum—more accurate knowledge.

It is admitted on all sides that many British fisheries are suffering, or are in a precarious state—others are actually destroyed. It is also admitted that our only chance of bettering this state of things is an increase of scientific or accurate knowledge.

If this is the case, there will be one grand scientific result of the International Fisheries Exhibition, and that will be an increased attention to, and adequate provision for, the carrying on of zoological studies in relation to fishery-animals.

I can picture to myself the shape which this scientific result might take, and I should be very glad were it to commend itself to the many influential men connected with fisheries who have organised this Exhibition, and will have the direction of its final outcome.

If it is demanded that more accurate knowledge of fishery-animals shall be provided for the public use, then arrangements must be made to enable skilled zoologists to carry on the investigations required. To make such investigations, continuous residence for weeks or months at a time, by the sea-shore, is necessary. In France, Holland, Italy and the United States, sea-side laboratories have been constructed, which are provided with working tables, glass apparatus, aquariums, &c., and a staff of attendants and fishermen—to which naturalists can resort who desire to

carry on investigations upon the life-history of marine organisms. Very valuable researches have been made through the agency of these institutions, and there can be no question as to the facilities which they afford, and the inducement which their existence offers, to naturalists to occupy themselves with these particular studies.

By offering free accommodation in such a laboratory to competent investigators you may obtain a large amount of valuable results at a minimum of expenditure. In any such laboratory there would probably be one or two permanent officials who would be competent zoologists, charged with special subjects of investigation and receiving salaries—but in addition to these, the laboratory would throw open its resources to voluntary workers (as do the foreign laboratories of which I have spoken) and thus the working power and the general interest of the scientific world in these institutions and their work would be enormously increased.

I can imagine a National Fisheries Society or Association, such as may come into existence in connection with this Exhibition, building such a laboratory for the study of marine zoology in relation to fisheries, somewhere on the coast not too distant from London. Such a laboratory would stand near the shore, possess its own jetty and small harbour, with steam-launch for dredging and trawling, and other boats. Adjacent to it would be marine ponds for experiments in the culture of oysters, mussels, and whelks, and of various fish. The director of the laboratory and his assistant would be provided with houses forming part of the laboratory building. The basement of the laboratory would consist of large well-paved rooms fitted with tanks, and an apparatus for the circulation of sea-water. Here animals would be kept for observation, and the

produce of a day's dredging or trawling would here be sifted and sorted. On the ground-floor and first-floor would be spacious rooms, with large windows giving both north and south lights, and fitted with tables suited to the requirements of the microscopist. Small aquariums and pumping apparatus would also be provided in these rooms. Accommodation for ten workers, in addition to the director and his assistant, would thus be provided. In another room a complete zoological and piscicultural library would be established; and the means for writing and making drawings would be provided.

The naturalists permanently and temporarily working here would in the course of a few years provide us with much-needed knowledge. For instance, some would study the reproduction of the sole, and devise means for increasing its numbers in the market; others would ascertain how best to deal with oysters; others would find out the whole history of the mussel. Bit by bit a new and thorough knowledge of fishery-animals would be built up, and come into use as the basis of new legislative enactments, and of new methods of capture and culture.

Such an institution would no doubt be costly. A valuable laboratory of the kind might be set going and carried on for a smaller sum; but a really creditable and efficient laboratory of the kind, with a first-rate man of science for its director, would cost £15,000 or £20,000 to establish, and some £3000 a year to maintain.

These figures and the whole suggestion may appear extravagant to some persons who are not aware of what has been done elsewhere.

The "Zoological Station" of Naples, founded and directed by Dr. Anton Dohrn, is no less costly and efficient an institution than that which I have briefly sketched. Else-

where, at Trieste, at Concarnean, at Roscoff, at Beaufort in North Carolina, less costly institutions have been set going, which are doing most valuable work.

The British coast is entirely destitute of any such home of research. No zoologists are employed by the Government or other authorities in this country to investigate our fishery-animals: those zoologists who do carry on such work on the coasts of this country, do so at their own expense. There is not even a laboratory, a boat or a dredging apparatus, provided by any public body to assist them. Naturally enough their work has not been hitherto specially directed to problems connected with fisheries; but it is only needful to offer to the many isolated investigators the use of a good laboratory and a well-considered organisation, in order to obtain through their co-operation the new knowledge which is so urgently needed.

I cannot but think that it will be a matter for profound congratulation to those who have brought this Exhibition into existence, to the Legislature, to men of science and to those concerned in fisheries, should we be able in future to point to a "National Laboratory of Marine Zoology" as THE Scientific Result of the London International Fisheries Exhibition.

DISCUSSION.

PROFESSOR BROWN GOODE proposed a vote of thanks to Professor Lankester for the masterly essay he had read. The results which should arise from the present Exhibition had interested him very much from the first time of its proposition, and on coming to England he had been much interested to see how the various journals were casting about to see what the results were to be. It was suggested that

the price of fish might be lowered, that many kinds of fish now not appreciated would come into favour, that the fishermen should get a larger share of profits and so on—each person seeming to have a special idea of his own; but Professor Lankester had really touched the core of the whole matter in showing that the chief results must be the scientific results. It seemed to him that the spread of actual scientific knowledge concerning fish and fisheries was one of the things which, above all others, would be the most profitable and satisfactory outcome of this Exhibition, and Professor Lankester had shown very clearly many of the ways in which that object might be attained. He had mentioned several important things, and amongst others he had called attention to the apparent opposition between scientific and practical men. The practical men had, he confessed, been rather an amusing feature of this Exhibition; some of them had stood on the platform and cried out against the views of men of science; but he thought any one who examined carefully the printed reports would find that the most practical papers had been those read by the scientific men, and that it was quite unnecessary for some of the "practical" men to disclaim scientific knowledge, because the lack of such knowledge was quite evident from the tenour of their remarks. Only the other day, however, he had the pleasure of listening to a paper by Mr. Cornish on the mackerel fisheries, which was an excellent example of the work of a man who has a thorough practical knowledge of the subject on which he spoke, and yet who in every sentence of his paper showed that his mind worked in a thoroughly scientific groove; he made his observations carefully and conscientiously, and from those observations deduced conclusions which were quite beyond criticism. Another important point, which the pre-

sent paper called attention to, was the thoroughly legitimate manner in which scientific men could apply a scientific method to practical subjects; and on behalf of those in the United States who claimed to be zoologists, and who had at the same time been trying to work out practical problems, he thanked Professor Lankester for the endorsement which he, as an English man of science, had given to the opinion that scientific investigation was not necessarily disconnected with practical results. There were some amongst scientific men who rather looked down upon any investigation which had a practical result, but it seemed to him that such a course was quite untenable, and that "the pursuit of knowledge for its own sake" was thoroughly compatible with the consciousness that some of the human race were to derive from the effort immediate benefit. Professor Lankester had spoken of the literature arising from the Exhibition, and also of the influence of these Conferences, and he thought that point deserved to be brought out even more fully. There had certainly been some extremely original and valuable papers published; and even the Catalogue itself, which Mr. Trendell had so admirably edited, contained many important scientific papers interspersed with its pages, and was a contribution of considerable importance to science. Some of the Papers read at those Conferences had been thoroughly original, and were worthy of publication in the memoirs of any scientific society; and he would suggest that one of the most important scientific results of the Exhibition, if it could be secured, would be to have published officially a series of Papers, of which the one now under discussion might well form the first, in which the teachings of each section of the Exhibition should be pointed out by some man of science. This would be a permanent index to the

teaching of the Exhibition, and would, he thought, prove very valuable.

Professor HUBRECHT seconded the motion. He thought one lesson to be drawn from the paper they had heard, which must be taken as a motto, was more knowledge, more science, and more zoology. Professor Lankester had spoken with appreciation of the interest which the Government of the Netherlands appeared to take in science, and in that respect he thought they had nothing to complain of. On the other hand, the legislation with regard to sea fisheries, which had been discussed very much at those Conferences, had been illustrated in the case of the Netherlands, which had already gone a good way in a certain direction, and he feared he had been rather premature, owing to sufficient scientific knowledge not having been acquired before the laws in question were passed. There was a large portion of the German Ocean, running a considerable extent into the land, which was much used as a ground for the herring, anchovy and flat-fish fisheries ; but fishing there with certain nets and fishing gear of a certain kind had been prohibited. This legislation only took place a few years ago, on the proposal of certain towns and villages on the coast, which represented that their fisheries were diminishing, and that they were gradually being starved out by over-fishing. These laws had now been passed, and a large police force organised to see that they were carried out ; but the results had almost staggered some of those who were favourable to this legislation, and the question was whether they were to go on on the same principle. Their faith had been especially shaken by two things. First, the population, which principally subsisted on fisheries—who brought the young fry of the herring into the market and sold them to large establishments, where they were used for feeding ducks ;

which again produced eggs, which were brought into the market, and thus there was a conversion of the inorganic material which the sea produced into serviceable food for man—had now lost their means of livelihood. In the same way it was said that by trawling the ground the spawn of other fishes was greatly disturbed; and an outcry was made against fish being used for manure, which had died in the nets and could not be used in any other way. It was said that if these young fish had not been caught, they would have grown up, and might have been captured hereafter, and served as food, but it was forgotten at the same time that when these young herrings had become adult, they might have swum away and come to the English, and so been caught by English fishermen. Secondly, there was an opinion, which had been openly avowed by some of the most eminent scientific authorities, that legislation with regard to sea fisheries ought not to be undertaken until the knowledge of the subject was more matured. This view was supported by the fact that, just before this law was enacted, after there had been years of the most destructive fishing going on, as it was said, there came a year in which the amount of fish taken was really marvellous. This legislation had now been going on for two or three years, and the results were so unsatisfactory to even those who were most in favour of it, especially those who were directly interested in the matter, that they were now thinking whether it would not be advisable to urge upon the Government a change in the legislation, as far as these sea fisheries were concerned. It did not follow at all from this that legislation should never be attempted, but only that it should not be undertaken without sufficient knowledge of the fish which inhabited the part of the ocean in question; their habits, origin, and migrations; the development of their eggs, and the

way in which this was interfered with by the fishing which was going on. He therefore endorsed from the bottom of his heart the principle for which Professor Lankester had contended, that there must be inquiry, and still further inquiry, before legislation based on scientific and accurate principles could be carried out.

(The resolution was then put and carried unanimously.)

The MARQUIS OF EXETER then proposed a vote of thanks to His Grace the Duke of Argyll for his kindness in coming to preside on this occasion.

MR. WALLEM seconded the motion, which was carried unanimously.

The CHAIRMAN, in responding, said he took a deep interest in the subject of the lecture, and it had been to him a great pleasure to hear so interesting and striking a Paper. It was so full of interest, that almost every sentence suggested matter for reflection. In the first place he thought Professor Lankester had been rather killing the slain when he inveighed against the objection taken by some practical men to purely scientific investigation. Some few years ago the fear might be entertained that this objection would place some obstacle in the way of science, but at present the applicability of science to the practical uses of life, and the immense advances which had been made in the applications of science, had particularly struck the public imagination and reason, and every one now but the most ignorant recognised the enormous value of science. The truth was, he had heard a serious complaint made that some of our most distinguished men of science had their time so occupied in patents, and directing the practical application of abstract science to the uses of life, that they had barely time for teaching pure science. At the same time they could never be too serious in the assertion of the principle that science pursued

truth for its own sake; that scientific men delighted in the ascertainment of truth for its own sake; and that they need care little or nothing for its future practical application. Professor Lankester had also said a few things in respect to Government which were no doubt to some extent true, but in regard to them also he would put in a word in favour of the class of public men to which he belonged. It had been said that Government in this country hardly ever consulted men of science. That might have been so in former times, but it was not so now; for, with regard to this very matter of fisheries, it was not many years ago that the Government committed a most important investigation to the hands of his distinguished friend, Professor Huxley, as the head of a commission that went to Scotland to inquire into what was the practical application of the laws then in force for the regulations of that kind of fisheries, and on the report of that distinguished Professor, very considerable alterations were made in the laws then in force. Passing from this general point, he would say a word or two with regard to the question of legislation on fisheries. He had had considerable means of observation and experience with regard to the application of the former laws to the herring fisheries on the coast of Scotland, and he was bound to say that he agreed in the general conclusions of Professor Huxley, that they did not know quite enough of the life and habits of the herring, for instance, to be able with any satisfaction to make a close time, or to prohibit any particular mode of fishing. He happened to live on Loch Fyne, which was celebrated for herring; it used to be the annual resort of enormous shoals of herrings, and under his own windows he had seen as many as 100 boats putting out to sea; but, for the last twelve or fifteen years, herrings appeared to have deserted the upper reaches of Loch Fyne.

Amongst the fishermen it was the universal belief that this absence of the herring shoals was due entirely to a new mode of capture which had been practised to a very large extent, and which was there called trawling. It had nothing to do with what was called trawling in the south, which meant a net dragged along the bottom of the sea for flat fish; but trawling, as it was locally called, meant drawing a seine net, such as was used for the mackerel fishery on the coast of Cornwall. That was an entirely new mode of fishing for herring at that time in the west of Scotland. The old orthodox mode was what was called a hanging net, which was a very large net, hundreds of fathoms long, which hung like a wall in the water, and intercepted the shoals of herring, which at night swam against it, and got entangled in the meshes. There was no motion of the net, it was perfectly still in the water, and was taken up when it was felt by the fishermen to be full. The new mode of fishing was by drawing the net into the shore or a boat, and it was the fixed belief of the old fishermen that the mere fact of drawing the net through the water frightened the shoals, and prevented them coming up: it, as they called it, broke the shoals. There were consequently some severe laws passed against trawling, which were most difficult to enforce, because in a very intricate coast like that of the west coast of Scotland—and his own country had upwards of 2000 miles of coast—it would require an immense body of police to enforce such a law; because seine nets were easily got and easily hid, and, in short, the expense which would be incurred, and the bad feeling which would be raised in trying to enforce these laws, made it a serious question with the Government whether they should be continued or not. Professor Huxley's conclusion was that no particular mode of fishing had any effect on the shoals of herring, but that one was just as

injurious as the other; and that it was no use to maintain these laws, and accordingly they had been repealed, and all modes of fishing were now free. He could not say that he had made up his mind on the question. Professor Huxley said that the enemies of the herring were so many, that the utmost number that man could take was as nothing to the number of herrings which were destroyed by their natural enemies. He had entered into various calculations with regard to the number of herrings eaten by every kind of fish, and by birds, especially by the gannet, which were more or less satisfactory, but he must say he had some misgivings as to the accuracy of those calculations. For example, he did not believe it to be true that the cod fish lived principally on herring. A cod fish, like himself, would always take a herring when he could get it, especially a Loch Fyne herring; but he happened to know from his own experience that the cod fish of Loch Fyne, especially during the winter, did not feed on the herring, because he made it a practice to examine what they had been feeding on when taken, and could say, as a positive fact, that during the winter months he hardly found a herring in the stomach of a cod fish. They lived principally on crabs of various kinds, and to a large extent on a particular kind of star-fish, the ophiurus, which lived in muddy bottoms. He had found the stomach of a large cod filled with this apparently hard and innutritious substance. Then with regard to the gannet, a large bird of which he was particularly fond, he did not believe that he lived entirely on the herring. He had seen it diving in immense numbers on shoals which he had the best reason to believe were not herring at all, but the common coal fish, or pollock whiting. He, therefore, doubted much the data on which these calculations were made. Another thing with regard to the herring

was this. When there was a large mass of herrings in a shoal, there was no fish which would venture to the centre of that enormous legion. He did not know that he ever realised what a shoal of herrings was, though he had often seen the boats in Loch Fyne, until last year when he happened to go in his yacht to the head of Loch Hourn. Soon after they anchored to the head of the loch, they observed that the herring boats were coming up behind, and long before sunset the yacht was surrounded by several hundreds of boats. They soon had indications that the shoals were moving, and before sunset they began to see the fish jumping all round. The boats shot their nets, and within half-an-hour there was not one net that was not so full that they were sinking to the bottom. They rowed about during the night to see the men lifting the nets, and some were one solid mass of fish, so solid that four or six men were unable to lift the net, and in several cases he had to lend his own men to help them lift their nets into the boats. The next morning the whole fleet were going down to the lower reaches of the loch to get their fish salted, and some of them were level with the water, so that the slightest undulation would have sunk them, but fortunately the sea was very calm. The fishermen said, with regard to shoals of herring of that kind, there were no predaceous fish which would enter into the midst of them, that they would be suffocated and smothered by the mass of herring. Therefore he thought all these calculations were matters of extreme doubt. One of the greatest mysteries with regard to herrings was this: Loch Hourn was a long, narrow inlet into the mountains opening out on the island of Skye, but these shoals were never seen before they got into Loch Hourn. The question was, where did they come from? they must come from the open ocean somewhere, but they

were never seen until they got into the head-waters of the loch, where they were caught in large numbers, and the fishing lasted three or four months. Of all these matters they were absolutely ignorant. On land they could examine closely the habits of animals, their modes of propagation, and their food, and so on; but with regard to fish, they could not go under the water, or follow them into their haunts, and they really did not know what their habits were. He was quite willing to admit that observations in an aquarium might be of the highest scientific value; but he need hardly say that in an aquarium you could never get really into the secrets of the migratory habits, which was the important point with regard to such a fish as the herring. With regard to legislation, if it were the object to save the herring, a law should be passed to prevent the fry being caught; and yet Professor Günther, one of the greatest authorities on fish in this country, declared that whitebait, one of the greatest luxuries of London, was nothing but young herring; so that one of the most lucrative and popular fisheries on the coast near London was one which destroyed millions of fry of that invaluable fish, the herring, yet nobody proposed that this should be prohibited. One of the most interesting parts of the lecture was that which dealt with the cultivation of fresh fish. Naturally in this country, being an island, sea fish were principally thought of, salmon being almost the only great article of commerce in the way of fresh-water fish; but Professor Lankester had pointed out that in other countries the cultivation of fresh water fish, as part of the food of the people, was an important item; and he was never more struck with this than when going into the market place at Dresden and Munich, and some of those towns in Central Germany where the people had no access to sea fish, but where he

found the market quite full of very nutritious food derived from the ponds, lakes, and rivers of the country. He could not help hoping that, as one of the results of this Exhibition, people would undertake fish ponds, just as they undertook ponds for water-cress in the neighbourhood of London. Some ponds near London, not much larger than that room, yielded very large rents from the growth of water-cress, and he hoped that ponds would also be established for the sale of fresh-water fish, because carp, tench, and other fish might be grown to a very great extent. But then they would have to get over some popular prejudices which existed in the minds of the poor, though probably not so much in England as in Scotland. For example, eels were a very favourite food in London; but, in the west of Scotland, a Highlander would as soon think of eating a serpent as an eel; in fact, they thought they were serpents, and although they had lakes and ponds full of the finest eels, they would not touch them or look at them in the way of food. In the lagoons of Venice there was an enormous fishery of eels, which were sent all over Europe in a salted condition. With regard to the culture of trout, he did not suppose that would ever come to be such an important industry for the food of the poor as others might be; but there were some curious facts in regard to it, of which he was reminded by some observations in the paper. Professor Lankester had referred to crustacea, which was the food of fishes, and that was a subject very little known in this country. The peculiar red colour of salmon, which was the only fish, so far as he knew, in the world which had that colour, sharing it, of course, with other members of the salmonidæ and trout family, was, in the opinion of Professor Günther, owing to the peculiar crustacea that it ate. Almost all the crustacea, when

boiled, became of a very red colour, some a very brilliant red, and the same thing occurred when they were digested. If you took a crustacean, half digested, out of the stomach of a fish, you would almost always find it of a red colour; and Professor Günther said that it was this peculiar colouring matter which gave its richness to the salmon. There was this peculiar circumstance about the trout, that some lochs contained trout of a highly red colour. He knew some lochs in the Highlands of Scotland where the trout were very fine, and quite as red as salmon; but he had never been able to discover that there were any peculiar crustacea in those waters. In the case of other lochs on the same hill, not perhaps 200 yards off, the trout were white, and in very inferior condition. These were points of extreme interest which might be scientifically investigated. Now the suggestion made by Professor Lankester, and he suspected the whole of his paper led up to this, was that the Government of this country did too little in these matters, and he was quite willing to plead guilty that the Government had done far too little for science. The system in England was for everything to be done by private enterprise, and hitherto it had been relied upon almost entirely. It was true we had our national geological surveys, but not even those were conducted on the scale which they were by the Government of the United States, whose splendid publications they were sometimes good enough to send him, illustrated by every species of drawing and section. He thought we did too little in the matter; but it was not very easy to know exactly where to begin. Professor Lankester had made a practical suggestion, which he said had been warmly taken up by some of the most distinguished men of science; Sir John Lubbock, Professors Sclater, Michael Foster, Burdon, Sanderson, Flower,

Romanes, Sedgwick, Mosely, Williams, Marshall, Thistleton-Dyer and Allman, and their recommendation was that a scientific observatory should be set up; a scientific aquarium, with fully equipped rooms for investigation and dissection of all kinds, as it had been at Naples, at the expense of the Government, for scientific investigation; and to the propagation of the life of fishes. This was a most important suggestion which he hoped would be brought before the Government, with all the influence and authority which these great names would undoubtedly carry with them. How far it was likely to be accepted he could not say, not being a member of the Government; but he should be very glad to give any help he could in the matter. He understood that the establishment at Naples, which had produced very valuable results, was set up, not by the Neapolitan or Italian Government, but by several Governments in Europe combining. He did not know why they should have fixed on the Mediterranean for such a purpose, because the fauna of the Mediterranean was essentially different from the fauna of the Atlantic and the Northern seas, and observations made there, although they might be of use for the Mediterranean, were not likely to be of such practical value as observations made on the fishes of our own shores. He believed to some extent the establishment at Naples paid its own way, because tables were hired out to various scientific persons, who came from all parts of Europe, and hired a table and tank for the investigation of particular phenomena. It was quite possible that such an establishment might be set up in this country, and that after all the ultimate cost to the Government might not be very large. He was sorry to detain the meeting so long, but he could not allow this interesting lecture to pass without saying something upon

it, and he heartily concurred in the vote of thanks which had been passed to Professor Lankester.

The document referred to by the Duke of Argyll is as follows—

"PROPOSAL FOR THE FOUNDATION OF AN OBSERVATORY ON THE BRITISH COAST FOR THE STUDY OF MARINE ANIMALS AND PLANTS IN RELATION TO FISH AND FISHERIES.

"The value to the FISH INDUSTRY of an increased knowledge of the habits and life-history of Fishes, has been proved by the experience of the American and French commissions. Without such knowledge we cannot improve our Fisheries commercially; with it, there is every probability that a great deal may be done in the way of controlling and extending them.

"In order to gain accurate knowledge as to the circumstances which affect the life of fishes, and the various molluscs, shell-fishes, corals and sponges, which are IMPORTANT COMMERCIALLY as well as interesting from the scientific point of view, it is necessary that continuous observations should be made upon their growth from the egg onwards, upon their food and its natural history, as well as upon their enemies and the conditions favouring, or injurious to, their life.

"Such observations can only be successfully carried out by persons resident on the sea-coast.

"In order to enable competent observers to spend such time as they can afford for these studies to the greatest advantage, Zoological Observatories have been established on the sea-coast of foreign countries, but at present there is no such observatory on the British coast.

"The first observatory of the kind is 'the Zoological

Station' established by Dr. Dohrn at Naples, which is frequented by naturalists from all parts of Europe. Its buildings and aquaria represent an expenditure of £20,000, and its annual expenditure is over £4000.

"Similar observatories have been established by the Austrian government at Trieste, and by the French government at Concarneau, Roscoff and Villefranche.

"It has been for some years the desire of English naturalists to establish a zoological observatory on the British coast, which would be in charge of a competent resident superintendent, and fitted with aquaria, laboratories, and apparatus, and possessed of boats and dredging apparatus. Two or three fishermen would be kept in the pay of the observatory. The institution thus organised would be frequented at all times of the year by naturalists desirous of carrying on original investigations relative to the life-history and structure of marine organisms. Accommodation for as many as six such naturalists might be provided.

"The affairs of the observatory and the granting of permission to make use of its appliances might be entrusted to a small committee consisting (for example) in the first place of the Warden of the Fishmongers' Company, the Professors of Zoology, Botany and Physiology in the Universities of Great Britain and in the London Colleges, and the Secretaries of the Linnean and Zoological Societies of London.

"Were such an observatory once established there is every reason to believe that funds could be raised annually for the purpose of extending its operations and of carrying on special work in it by grants from scientific societies, the universities and such sources.

"The obstacle hitherto to the establishment of a British